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J. Billingsley

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AUSTRALIA

Patents Act 1990

PROVISIONAL SPECIFICATION

Applicant(s):

BM ALLIANCE COAL OPERATIONS PTY LTD

Invention Title:

METHOD AND APPARATUS FOR PROCESSING PARTICULATE MATERIAL

The invention is described in the following statement:

METHOD AND APPARATUS FOR PROCESSING PARTICULATE MATERIAL

Field of the Invention

This invention relates to a method and apparatus for processing particulate material and, in particular, minerals and carbonaceous solids such as coal, iron ore, manganese, diamonds and other materials The invention has particular application to the processing of coal, and will be further described in relation to the processing of coal. However, it should be understood that the invention is applicable to processing other materials including but not restricted to those mentioned above.

Background of the Invention

Raw coal is mined from the ground and is processed to provide a desirable commercial product. Raw coal includes a certain amount of gangue mineral content which, following combustion under standard condition, leaves a solid ash residue. Saleable coal most preferably has a fixed ash specification limit which is normally specified in contractual agreements between the producer and the purchaser. A typical example of an ash specification for high quality coking coal is 10%. If the ash level of produced coal increases above this level, the product may still be saleable but its price is deleteriously affected and/or some penalties for the producer may be incurred.

Raw coal after mining may be separated into a particular particle size by a screen mesh type or other classification-type device to separate the raw coal into predetermined particle sizes defined by, for example, the screen aperture size of the screen separator.

The separated coal of the desired size is then supplied to a dense medium separator. There are a number of different dense medium separators currently in use depending on the size of particles being treated. For example, large lumps

may be processed in heavy medium drums, heavy medium baths, heavy medium vessels, larcodems etc, and smaller but still coarse particles may be processed in heavy medium cyclones, heavy medium cycloids etc. Note that the words "heavy" and "dense" can be used interchangeably in this context. These types of heavy medium devices use a benign or inert finely ground powder of medium solids (such as magnetite or ferro-silicon) slurried in water to form a dense medium whose density can be automatically controlled by the proportion of solids in the slurry. Mixing the raw coal with the dense medium enables separation on the basis of its density relative to the density of the dense medium. For example, coal with an ash level of 10% may be separable from higher ash components of the raw coal by adding the raw coal to a dense medium of, for example, 1400kg/m^3. In this example, the 10% ash product coal might float clear of the higher ash material which might tend to sink in the dense medium. The material that floats would report to the overflow outlet of a separator and that which sinks would report to the underflow outlet.

For the specific case of a dense medium cyclone, it is separating efficiency of the coal particles that is often critical to maximising yield and recovery. The accepted industry standard for measuring efficiency is the partition coefficient curve with its characteristic D_{50} and Ep parameters. The D_{50} is the separating density of the particles and the Ep is a measure of the sharpness the separation (a higher value of Ep indicates more misplacement of particles and hence a lower efficiency). Whilst the D_{50} of a separation is strongly related to the medium density, there are machine effects that lead to, almost invariably, the D_{50} being a little higher than the medium density. The extent to which it is greater is dependent on a number of parameters, including, but not limited to, medium density, dense medium cyclone pressure,

raw coal feed rate, and variations therein. The overall sharpness of separation is a strong function of variations in each of these parameters (medium density, pressure and feed rate).

Measurement of the density of medium slurry is performed by, for example, nucleonic gauges or differential pressure transducers. Measurement of pressure of the material feeding a dense medium cyclone is performed with pressure transducers and the like, while plant feed rate is determined with weightometers on the conveyor belt feeding the plant.

Each of these three parameters may be incorporated into individual control systems which attempt to maintain operational values of these parameters within acceptable limits. However, control systems are imperfect and variations occur during normal industrial operations. Variations in the medium density, pressure and feed rate cause separations to occur at densities (D_{50}'s) different from those desired. Momentary fluctuations that lead to higher D_{50}'s than desired will result in higher proportions of the raw coal being collected at the separator floats or overflow outlet. A momentary change in product quality will occur with a higher ash material separated. Similarly, the momentary changes in product quality will occur when fluctuations lead to lower D_{50}'s which result in decreases in the ash of the separated material.

Whilst plant control systems almost invariably allow product within ash specification to be separated, this is often achieved at the expense of yield and recovery. Maximum yield or recovery at a given product quality is achieved when fluctuations in each of medium density, pressure and feed rate are minimised.

Summary of the Invention

The object of the invention is to provide a method and apparatus for processing particulate material, such as coal, in which yield or recovery losses can be reduced.

The present invention may be said to reside in a method of processing particulate material, including the steps of:

supplying the particulate material to a separator;

monitoring a parameter of the device indicative of the separation density of the material;

determining from said parameter an induced value indicative of the separating efficiency of the material that passed through said separator;

comparing said value with a predetermined value; and

generating an alarm condition if the said value departs from the predetermined value by a predetermined amount.

Thus, according to the invention, if the effective separating efficiency departs from the required separating efficiency by a predetermined amount an alarm signal is generated. This enables remedial action to be taken to correct whatever fault has caused the change in the separating efficiency of the dense medium device, thereby returning the separating efficiency to its desired level to decrease the loss due to fluctuations in the separating density of the material. In other words, the fluctuation cycle of the separating density can be more quickly responded to so as to reduce both the magnitude and time of the fluctuations to reduce yield and recovery losses caused by those fluctuations.

Preferably the separator comprises a heavy medium device containing a dense medium.

Preferably the step of determining the induced value comprises determining an induced set of values indicative of the separating efficiency of the material that passed through the device, the step of comparing said value comprises comparing said set of values with a predetermined range for the set of values, and the step of generating the alarm condition comprises generating the alarm condition if the said set of values departs from the predetermined range for the set of values by a predetermined amount.

The set of values may be in the form of a partition coefficient curve and parameters derived therefrom.

In the preferred embodiment of the invention, the parameter which is monitored is the actual density of the medium.

However, in another embodiment, the parameter is pressure of the medium and particle mixture which is supplied to the device.

In a still further embodiment the parameter is the feed rate of the medium and particle mixture supplied to the device. A practical proxy for this is the overall processing plant feed rate.

In a still further embodiment of the invention, two or more of the medium density, pressure of the medium and particle mixture, and feed rate of the medium and particle mixture are monitored.

In the preferred embodiment of the invention, the density of the medium is measured at predetermined time intervals, and for a predetermined time period, the number of measurements at each measured value is determined to produce a cumulative frequency distribution of the length

of time the particle spends at each measured density, and said set of values characterising separating efficiency is determined as a medium induced partition coefficient curve and/or a parameter derived therefrom, for example medium induced Ep value (MIEp value) by taking the absolute value of the difference in density at the 75th and 25th percentiles, and dividing by 2 so as to produce an MIEp value which is a theoretical value solely dependent on medium density variations, and comparing the MIEp value with the said predetermined value, or medium induced partition coefficient curve with a predetermined partition coefficient curve.

In the other embodiments of the invention a feed rate induced partition coefficient curve and/or a parameter derived therefrom, for example feed rate induced Ep(FRIEp) value is determined in the same manner from the feed rate measurements made over the predetermined time period. However an empirical calibration will be required to convert feed rate variation to D_{50} variation so as to produce a cumulative frequency distribution of separating densities and so provide the length of time spent at each separating density. In the case of measuring the pressure of the medium and particle mixture, a pressure induced partition coefficient curve and a derived pressure induced Ep(PIEp) value is determined so that individual values over the predetermined time period are used to calculate a cumulative frequency distribution of separating densities, giving the length of time spent at each separating density. Once again an empirical calibration is required to convert pressure measurements to separating density (D_{50}).

The present invention may be said to reside in an apparatus for processing particulate material, including:

a heavy medium device containing a dense medium;

means for supplying the particulate material to a

separator;

means for monitoring a parameter of the device indicative of the separation density of the material;

processing means for determining from said parameter an induced value indicative of the separating efficiency of the material that passed through said separator;

comparing means for comparing said value with a predetermined value; and

alarm means for producing an alarm condition if the said value departs from the predetermined value set by a predetermined amount.

Preferably the separator comprises a heavy medium device.

Preferably the processing means determines from said parameter an induced set of values indicative of the separating efficiency of the material that passed through the device, the comparing means compares the said value set with a predetermined value set and the alarm means is for producing the alarm condition if the set of values departs from the predetermined value set by a predetermined amount.

The set of values may be in the form of a partition coefficient curve and parameters derived therefrom.

In the preferred embodiment of the invention, the monitoring means measures the density of the medium at predetermined time intervals, and for a predetermined time period, and the processing means determines the number of measurements at each measured value to produce a cumulative frequency distribution of the length of time the particle spends at each measured density, and determines said value set as a medium induced partition coefficient curve and/or parameters derived therefrom, for example medium induced Ep value (MIEp value) by taking the

absolute value of the difference in relative density at the 75^{th} and 25^{th} percentiles, and dividing by 2 so as to produce an MIEp value which is a theoretical value solely dependent on medium density variations, and comparing the partition coefficient curve and parameters derived therefrom, for example, MIEp value set with the said predetermined value set.

In the other embodiments of the invention a feed rate induced partition coefficient curve and parameters derived therefrom, for example Ep(FRIEp) value set is determined in a similar manner from the feed rate measurements made over the predetermined time period. As feed rate to dense medium separators is not commonly measured directly, overall processing plant feed rate is used as a proxy. However an empirical calibration will be required to convert feed rate variation to D_{50} variation so as to produce a cumulative frequency distribution of separating densities and so provide the length of time spent at each separating density. In the case of measuring the pressure of the medium and particle mixture, a pressure induced partition coefficient curve and parameters derived therefrom, for example, pressure induced Ep(PIEp) value set is determined in a similar manner from the pressure measurements made over the predetermined time period. However an empirical calibration will be required to convert pressure variation to D_{50} variation so as to produce a cumulative frequency distribution of separating densities and so provide the length of time spent at each separating density.

Brief Description of the Drawings

A preferred embodiment of the invention will be described, by way of example, with reference to the accompanying drawings in which:

Figure 1 is an illustrative diagram illustrating apparatus for processing coal;

Figure 2 is a block diagram illustrating the operation of the preferred embodiment of the invention;

Figure 3 is a graph showing the mass percentage of feed to the medium density device which reports to product against density of the medium;

Figure 4 is a graph showing the accumulative frequency distribution for an ideal situation; and

Figure 5 is a graph of the type of Figure 4 exemplifying what may occur in actual practice.

Detailed Description of the Preferred Embodiments

The following is a specific example of a generic dense medium cyclone circuit. It is given as a means only of explaining how the invention can be applied and does not limit the coverage of the invention to the specific example given.

Prior to entering the process depicted in Figure 1, raw coal may be reduced to 50mm top size. With reference to Figure 1, raw coal is separated on a sieve bend 1 followed by a vibratory screen 2 with wash water addition 3. This device removes fine particles, typically 2-0.2mm, from the raw coal and all the undersize is processed in devices not mentioned here. The oversize material gravitates to sump 4 from which it is pumped 5 to the dense medium cyclone 6. It will be noted on Figure 1 that dense medium is added to the coarse coal particles in the dense medium cyclone feed sump 4. The coarse raw coal is separated in the dense medium cyclone 6 to produce a lower ash product and a higher ash reject. The product is separated from the dense medium on sieve bend 7 and drain 8 and rinse screen 9. The sieve bend and drain screens remove the bulk of the dense medium which can then recycled to the dense medium sump 14. The rinse screen 9 uses water addition 21, 22 (dirty and clarified) to aid the removal of medium adhering to the coal particles. Rinse screen underflow is significantly diluted and must be concentrated such that

the water is removed before it can be reused in the operation of the dense medium cyclone. Similar sieve bend 10, drain 11 and rinse 12 screen recovery of dense medium occurs for the dense medium cyclone underflow material.

The diluted dense medium is dewatered with magnetic separators 16 and 17. The recovered dense medium is passed to the over-dense sump 18 from where it is pumped 15 to the dense medium sump 14. The separated water is recycled for use elsewhere in the plant, including water addition to the screening operations described above.

Also shown on Figure 1 are the locations of measuring devices for medium density D, pressure P and feed rate F.

It should be noted once again that this is a very brief and simplified description of the generic circuitry for coal processing.

The density of the dense medium supplied to the mixture with the particulate material is measured with a nucleonic or differential pressure transducer D.

The pressure of the medium density and particulate mixture supplied to the dense medium cyclone is also measured by pressure transducer P.

In the preferred embodiment of the invention, the density measurements made by the nucleonic or differential pressure transducer D are used to generate an alarm condition, should the medium induced partition coefficient curve and/or parameters derived therefrom change from the desired values so that remedial action can be taken to restore the desired density control and thereby minimise losses caused by fluctuations or variations in the density of the medium density. However, as has been previously described, the pressure measurements or feed rate

measurements may be used in combination with the density measurements or instead of the density measurements in order to continually monitor the fluctuations in medium induced partition coefficient curve and/or parameters derived therefrom to enable the alarm condition to be generated and remedial action immediately taken to restore the required level of control of the dense medium separation.

With reference to Figure 2, the density measurements from the nucleonic or differential pressure transducer D are fed to a processor 50, typically maintained in, but not limited to, the coal plant operation room when in the desired location, or any other suitable location. The pressure and feed rate measurements from the pressure transducer P and weightometers F are also fed to the processor 50.

According to the preferred embodiment of the invention, measurements are read frequently, for example every 1 minute, and those measurements are taken over a predetermined time period of, for example 30 minutes to 2.5 hours, may be used to determine the value set for comparison with the predetermined value set in order to determine whether the alarm condition needs to be generated.

Table 1 below shows exemplary measurements which may be taken over a time period of 2 hours 45 minutes and used for processing in the processor 50.

TABLE 1

TIME	Density kg/m^3	TIME (cont.)	Density kg/m^3 (cont.)	TIME (cont.)	Density kg/m^3 (cont.)
10:56:00 AM	1,269.20	9:11:00 AM	1,265.10	7:26:00 AM	1,271.80
10:55:00 AM	1,268.10	9:10:00 AM	1,268.00	7:25:00 AM	1,267.70
10:54:00 AM	1,266.50	9:09:00 AM	1,265.90	7:24:00 AM	1,260.20
10:53:00 AM	1,261.60	9:08:00 AM	1,266.60	7:23:00 AM	1,260.70
10:52:00 AM	1,258.80	9:07:00 AM	1,265.70	7:22:00 AM	1,265.00
10:51:00 AM	1,261.10	9:06:00 AM	1,263.30	7:21:00 AM	1,268.60
10:50:00 AM	1,265.10	9:05:00 AM	1,260.70	7:20:00 AM	1,269.70
10:49:00 AM	1,265.70	9:04:00 AM	1,262.70	7:19:00 AM	1,265.40
10:48:00 AM	1,269.60	9:03:00 AM	1,266.90	7:18:00 AM	1,261.80
10:47:00 AM	1,271.80	9:02:00 AM	1,269.70	7:17:00 AM	1,262.40
10:46:00 AM	1,274.50	9:01:00 AM	1,264.00	7:16:00 AM	1,263.00
10:45:00 AM	1,274.80	9:00:00 AM	1,260.80	7:15:00 AM	1,266.10
10:44:00 AM	1,270.80	8:59:00 AM	1,262.20	7:14:00 AM	1,269.20
10:43:00 AM	1,266.90	8:58:00 AM	1,265.70	7:13:00 AM	1,269.50
10:42:00 AM	1,263.20	8:57:00 AM	1,269.20	7:12:00 AM	1,265.50
10:41:00 AM	1,260.90	8:56:00 AM	1,272.20	7:11:00 AM	1,261.10
10:40:00 AM	1,257.70	8:55:00 AM	1,264.30	7:10:00 AM	1,258.20
10:39:00 AM	1,257.00	8:54:00 AM	1,262.20	7:09:00 AM	1,258.90
10:38:00 AM	1,262.70	8:53:00 AM	1,261.50	7:08:00 AM	1,262.50
10:37:00 AM	1,267.60	8:52:00 AM	1,261.40	7:07:00 AM	1,264.80
10:36:00 AM	1,268.50	8:51:00 AM	1,266.80	7:06:00 AM	1,268.00
10:35:00 AM	1,266.90	8:50:00 AM	1,268.70	7:05:00 AM	1,270.40
10:34:00 AM	1,264.20	8:49:00 AM	1,266.60	7:04:00 AM	1,271.60
10:33:00 AM	1,266.10	8:48:00 AM	1,264.40	7:03:00 AM	1,266.40
10:32:00 AM	1,263.40	8:47:00 AM	1,264.00	7:02:00 AM	1,260.60
10:31:00 AM	1,263.80	8:46:00 AM	1,265.80	7:01:00 AM	1,256.90
10:30:00 AM	1,264.80	8:45:00 AM	1,264.40	7:00:00 AM	1,260.20
10:29:00 AM	1,266.90	8:44:00 AM	1,261.30	6:59:00 AM	1,261.90
10:28:00 AM	1,268.00	8:43:00 AM	1,263.30	6:58:00 AM	1,265.50
10:27:00 AM	1,261.60	8:42:00 AM	1,266.70	6:57:00 AM	1,269.80
10:26:00 AM	1,262.80	8:41:00 AM	1,269.60	6:56:00 AM	1,273.80
10:25:00 AM	1,266.50	8:40:00 AM	1,267.60	6:55:00 AM	1,270.90
10:24:00 AM	1,266.30	8:39:00 AM	1,266.90	6:54:00 AM	1,266.20
10:23:00 AM	1,266.60	8:38:00 AM	1,264.40	6:53:00 AM	1,263.40
10:22:00 AM	1,267.70	8:37:00 AM	1,260.80	6:52:00 AM	1,258.40
10:21:00 AM	1,265.60	8:36:00 AM	1,260.80	6:51:00 AM	1,257.60
10:20:00 AM	1,263.00	8:35:00 AM	1,262.20	6:50:00 AM	1,262.30
10:19:00 AM	1,261.50	8:34:00 AM	1,268.30	6:49:00 AM	1,263.90
10:18:00 AM	1,262.60	8:33:00 AM	1,271.80	6:48:00 AM	1,268.20
10:17:00 AM	1,264.70	8:32:00 AM	1,269.30	6:47:00 AM	1,272.70

10:16:00 AM	1,263.00	8:31:00 AM	1,265.00	6:46:00 AM	1,269.00
10:15:00 AM	1,265.20	8:30:00 AM	1,266.40	6:45:00 AM	1,263.90
10:14:00 AM	1,267.30	8:29:00 AM	1,264.40	6:44:00 AM	1,261.90
10:13:00 AM	1,267.70	8:28:00 AM	1,262.90	6:43:00 AM	1,259.40
10:12:00 AM	1,269.60	8:27:00 AM	1,257.70	6:42:00 AM	1,261.80
10:11:00 AM	1,273.00	8:26:00 AM	1,258.20	6:41:00 AM	1,264.60
10:10:00 AM	1,274.90	8:25:00 AM	1,263.70	6:40:00 AM	1,266.70
10:09:00 AM	1,274.60	8:24:00 AM	1,268.60	6:39:00 AM	1,270.60
10:08:00 AM	1,266.90	8:23:00 AM	1,269.30	6:38:00 AM	1,267.50
10:07:00 AM	1,259.70	8:22:00 AM	1,268.40	6:37:00 AM	1,264.10
10:06:00 AM	1,261.10	8:21:00 AM	1,266.00	6:36:00 AM	1,261.40
10:05:00 AM	1,268.50	8:20:00 AM	1,266.90	6:35:00 AM	1,259.50
10:04:00 AM	1,270.10	8:19:00 AM	1,262.80	6:34:00 AM	1,261.90
10:03:00 AM	1,265.30	8:18:00 AM	1,258.70	6:33:00 AM	1,267.30
10:02:00 AM	1,261.40	8:17:00 AM	1,258.90	6:32:00 AM	1,269.00
10:01:00 AM	1,259.70	8:16:00 AM	1,259.80	6:31:00 AM	1,271.20
10:00:00 AM	1,260.80	8:15:00 AM	1,264.90	6:30:00 AM	1,264.80
9:59:00 AM	1,264.10	8:14:00 AM	1,264.70	6:29:00 AM	1,262.60
9:58:00 AM	1,266.90	8:13:00 AM	1,266.10	6:28:00 AM	1,260.80
9:57:00 AM	1,269.40	8:12:00 AM	1,270.00	6:27:00 AM	1,260.60
9:56:00 AM	1,268.90	8:11:00 AM	1,270.70	6:26:00 AM	1,262.30
9:55:00 AM	1,265.70	8:10:00 AM	1,260.40	6:25:00 AM	1,264.80
9:54:00 AM	1,263.50	8:09:00 AM	1,259.00	6:24:00 AM	1,267.50
9:53:00 AM	1,262.50	8:08:00 AM	1,261.60	6:23:00 AM	1,270.30
9:52:00 AM	1,261.60	8:07:00 AM	1,265.20	6:22:00 AM	1,269.70
9:51:00 AM	1,258.90	8:06:00 AM	1,270.40	6:21:00 AM	1,263.50
9:50:00 AM	1,264.20	8:05:00 AM	1,271.80	6:20:00 AM	1,260.70
9:49:00 AM	1,270.20	8:04:00 AM	1,267.90	6:19:00 AM	1,260.20
9:48:00 AM	1,270.00	8:03:00 AM	1,264.80	6:18:00 AM	1,263.20
9:47:00 AM	1,265.40	8:02:00 AM	1,262.60	6:17:00 AM	1,264.00
9:46:00 AM	1,264.70	8:01:00 AM	1,259.70	6:16:00 AM	1,264.80
9:45:00 AM	1,264.40	8:00:00 AM	1,261.90	6:15:00 AM	1,266.60
9:44:00 AM	1,260.20	7:59:00 AM	1,268.30	6:14:00 AM	1,270.40
9:43:00 AM	1,262.80	7:58:00 AM	1,272.30	6:13:00 AM	1,272.10
9:42:00 AM	1,266.10	7:57:00 AM	1,266.10	6:12:00 AM	1,273.80
9:41:00 AM	1,271.20	7:56:00 AM	1,261.50	6:11:00 AM	1,276.00
9:40:00 AM	1,265.50	7:55:00 AM	1,261.60		
9:39:00 AM	1,259.00	7:54:00 AM	1,263.90		1,256.90
9:38:00 AM	1,260.60	7:53:00 AM	1,266.90		1,276.00
9:37:00 AM	1,267.10	7:52:00 AM	1,267.60		
9:36:00 AM	1,270.60	7:51:00 AM	1,266.30		
9:35:00 AM	1,265.50	7:50:00 AM	1,260.80		
9:34:00 AM	1,262.40	7:49:00 AM	1,261.70		
9:33:00 AM	1,261.00	7:48:00 AM	1,263.60		
9:32:00 AM	1,262.80	7:47:00 AM	1,267.30		
9:31:00 AM	1,264.80	7:46:00 AM	1,272.50		

9:30:00 AM	1,268.80	7:45:00 AM	1,267.70		
9:29:00 AM	1,269.10	7:44:00 AM	1,261.60		
9:28:00 AM	1,267.40	7:43:00 AM	1,260.40		
9:27:00 AM	1,265.80	7:42:00 AM	1,263.10		
9:26:00 AM	1,265.60	7:41:00 AM	1,269.40		
9:25:00 AM	1,263.20	7:40:00 AM	1,268.90		
9:24:00 AM	1,259.70	7:39:00 AM	1,263.30		
9:23:00 AM	1,262.80	7:38:00 AM	1,262.60		
9:22:00 AM	1,267.30	7:37:00 AM	1,264.00		
9:21:00 AM	1,269.80	7:36:00 AM	1,264.80		
9:20:00 AM	1,267.60	7:35:00 AM	1,266.50		
9:19:00 AM	1,264.90	7:34:00 AM	1,268.10		
9:18:00 AM	1,261.90	7:33:00 AM	1,265.40		
9:17:00 AM	1,262.40	7:32:00 AM	1,263.00		
9:16:00 AM	1,263.70	7:31:00 AM	1,261.40		
9:15:00 AM	1,266.60	7:30:00 AM	1,261.40		
9:14:00 AM	1,266.90	7:29:00 AM	1,262.40		
9:13:00 AM	1,264.30	7:28:00 AM	1,267.70		
9:12:00 AM	1,262.20	7:27:00 AM	1,270.30		

The values 1,256.90 and 1,276.00 given on the previous page at the end of the table represent the minimum and maximum densities measured during the time period of Table 1.

In table 2 set out below, the frequency distribution of the densities given in Table 1 are set out.

The normalised frequency is obtained by multiplying the frequency value by 100 and dividing by the sum of the normalised frequency column. The cumulative frequency is the addition of the particular normalised frequency by the sum of the previous normalised frequencies.

TABLE 2

Frequency Distribution					
Density Range			Frequency	Normalised Frequency	Cumulative Frequency
Lower	Upper	Mean Density			
kg/m3	kg/m3				
	1,256.80	1,256.80	0.00	0.00	0.00
1256.8	1,257.80	1,257.30	5.00	1.75	1.75
1257.8	1,258.80	1,258.30	5.00	1.75	3.50
1258.8	1,259.80	1,259.30	12.00	4.20	7.69
1259.8	1,260.80	1,260.30	18.00	6.29	13.99
1260.8	1,261.80	1,261.30	23.00	8.04	22.03
1261.8	1,262.80	1,262.30	28.00	9.79	31.82
1262.8	1,263.80	1,263.30	20.00	6.99	38.81
1263.8	1,264.80	1,264.30	30.00	10.49	49.30
1264.8	1,265.80	1,265.30	24.00	8.39	57.69
1265.8	1,266.80	1,266.30	23.00	8.04	65.73
1266.8	1,267.80	1,267.30	27.00	9.44	75.17
1267.8	1,268.80	1,268.30	16.00	5.59	80.77
1268.8	1,269.80	1,269.30	21.00	7.34	88.11
1269.8	1,270.80	1,270.30	13.00	4.55	92.66
1270.8	1,271.80	1,271.30	8.00	2.80	95.45
1271.8	1,272.80	1,272.30	5.00	1.75	97.20
1272.8	1,273.80	1,273.30	3.00	1.05	98.25
1273.8	1,274.80	1,274.30	3.00	1.05	99.30
1274.8	1,275.80	1,275.30	1.00	0.35	99.65
1275.8	1,276.80	1,276.30	1.00	0.35	100.00
1276.8	1,277.80	1,277.30	0.00	0.00	100.00
1277.8	1,278.80	1,278.30	0.00	0.00	100.00
1278.8	1,279.80	1,279.30	0.00	0.00	100.00
1279.8	1,280.80	1,280.30	0.00	0.00	100.00
1280.8	1,281.80	1,281.30	0.00	0.00	100.00
1,281.80		1,281.80	0.00		
			286.00	100.00	

The processor 50 then lines up the measured density values from lowest to highest so that the frequency of each measured value can be determined.

A chart is then prepared whereby the mid point of each density range is plotted against the density to give the partition coefficient curve.

The processor 50 then determines an induced value, which in the preferred embodiment uses the density measurements, is a medium induced Ep value from the cumulative frequency distribution of the length of time spent at each density by taking the absolute value of the difference in relative density at the 75^{th} and 25^{th} percentiles and dividing by 2 as shown by the following equation:

Equation $$Ep = \frac{75\% - 25\%}{2}$$

By way of further explanation, the inefficiency of the processing is generally given by the Ep value. Figure 3 is a graph showing the mass percentage of feed supplied to the medium dense separator 12 that reports to product. Figure 4 is a graph in an ideal situation showing that all of the feed reports to product, and if the above equation is applied to the data in Figure 4, it will be seen that the Ep value is 0, which gives a theoretically perfect result. That is, at both the 75% and 25% percentile, all of the feed reports to product. However, in real operating conditions, the graph of Figure 4 is more likely to look like that shown in Figure 5, where the slope of the line L gives an indication of the efficiency of the processing. Using the data supplied in Table 2 and Figure 5, the Ep value is (1.267 - 1.261)/2, which equals 0.003. The processor 50 is programmed to generate an alarm, should the calculated Ep value become, for example, 0.01. Thus, the graph shown in Figure 5 is indicative of a very good MIEp value indicating that remedial action does not need to be taken. If the value was above 0.01, an alarm condition would be generated. As shown in Figure 2, the processor may output a signal to an alarm 52 to generate the alarm, which could be an audible alarm or simply a visual indication on a monitor or a combination of both to

alert operators in the control room that fluctuations have exceeded a desired value and that remedial action should be taken to correct the situation to restore the proper medium density, and thereby restore maximum yield operation to the processing plant.

The remedial action which may be taken may be to dispatch workmen to inspect valves in the system to ensure that they are operating properly and have not jammed or closed, pipelines to ensure that there are no leakages, and other operating parameters of the equipment. Action can be taken by workmen to correct any fault which may be observed immediately, rather than awaiting routine inspections or the like which may result in a fault continuing for a continued period of time, and thereby resulting in significant loss in the yield from the plant until the remedial action is identified and taken.

MIEp values are periodically determined after an initial period of 2 hours 45 minutes by simply dropping off the first measurement made and adding to the total of measurements the next successive measurement made. For example, in the table of Figure 1, the next MIEp value may be calculated by dropping off the density reading for the time 6.11:00 and adding to the list of density values measured that for time period 10.57:00. This would provide a new MIEp value for comparison with the predetermined value every 1 minute. Obviously, if a greater period is desired, then additional earlier readings can be ignored and more subsequent measurements made before a further MIEp value is calculated.

In accordance with the preferred embodiment of the invention, the processing plant can be monitored to determine when its separating performance drops below required levels, thereby enabling remedial action to be immediately taken, and this could be worth millions of

dollars per annum to the operation.

In the second embodiment of the invention in which the pressure measurements are taken so as to produce a pressure induced Ep value, a similar algorithm to that described above is used with the inclusion of an empirically determined relationship between pressure and separating density. The pressure values are measured at the time intervals similar to that in Figure 1. The separating density is a function of the pressure and therefore the pressure values can be converted to separating density values which are accumulated in the same manner as described with reference to Table 2 so as to enable the Ep value to be calculated.

Similarly, in the embodiment which uses feed rate, the feed rate of material is measured as, for example, weight in tonnes per hour, and these values are again converted to separation density values so that an accumulation of separation densities can be used to enable the feed rate induced Ep value to be determined.

Since modifications within the spirit and scope of the invention may readily be effected by persons skilled within the art, it is to be understood that this invention is not limited to the particular embodiment described by way of example hereinabove.

Figure 1. Apparatus for Coal Processing

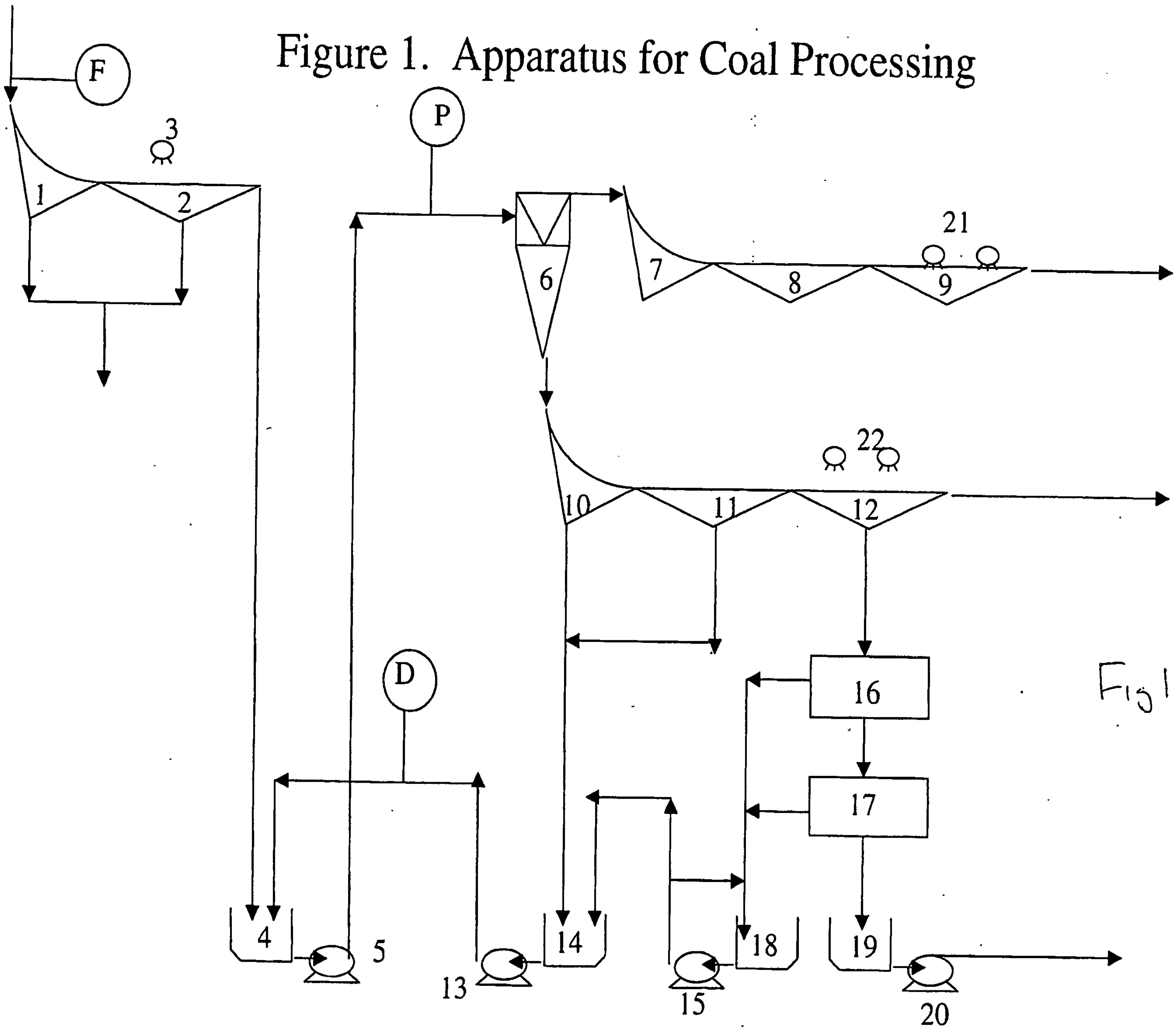

Fig 1

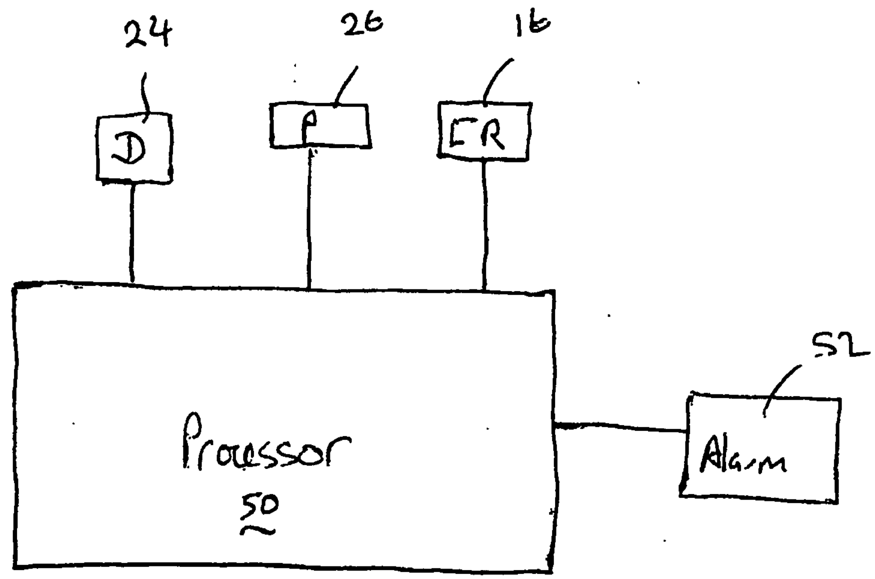

Fig 2

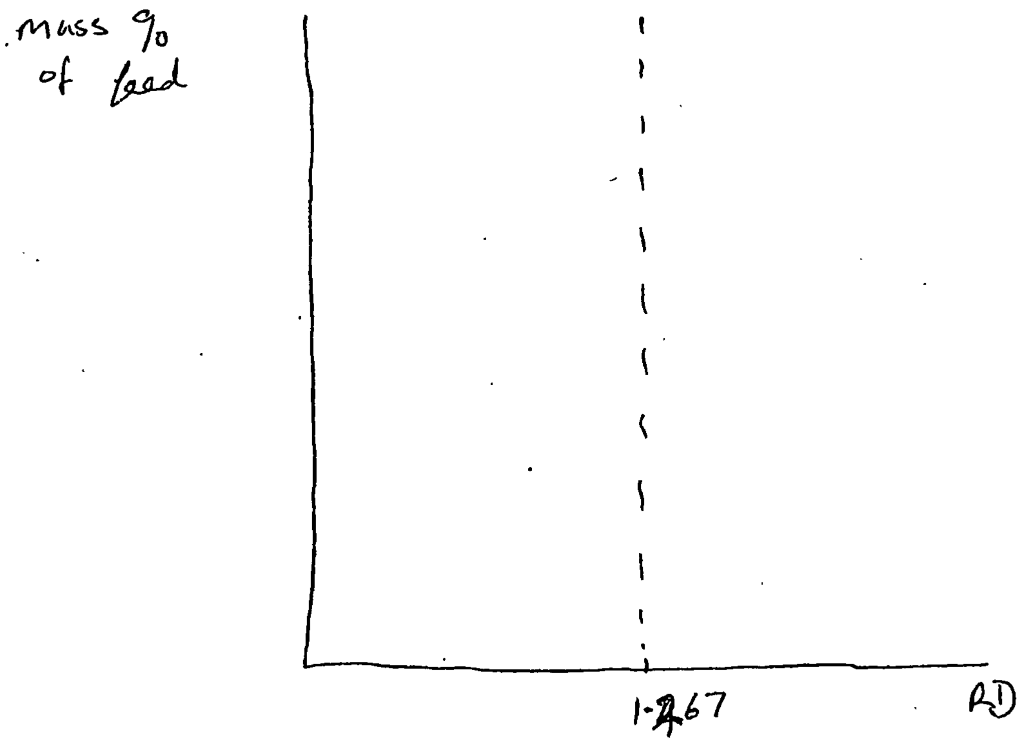

Fig 3

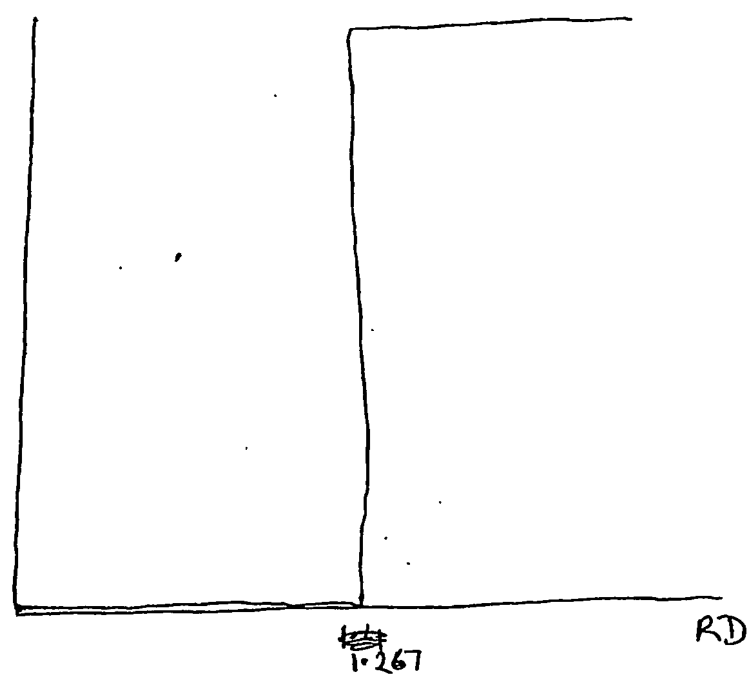

Fig 4

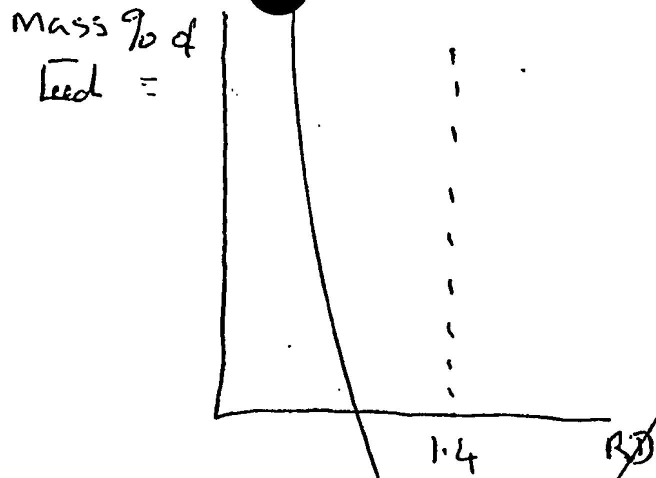

Fig 3

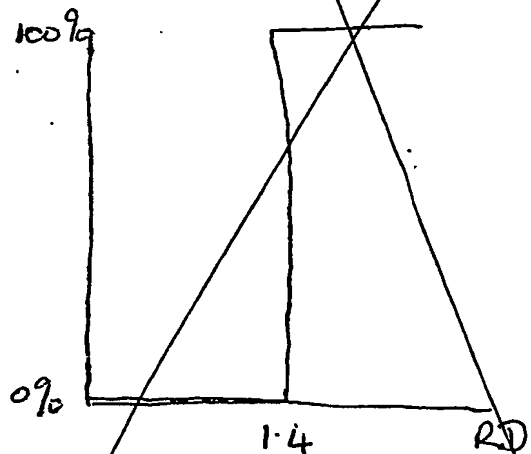

Fig 4

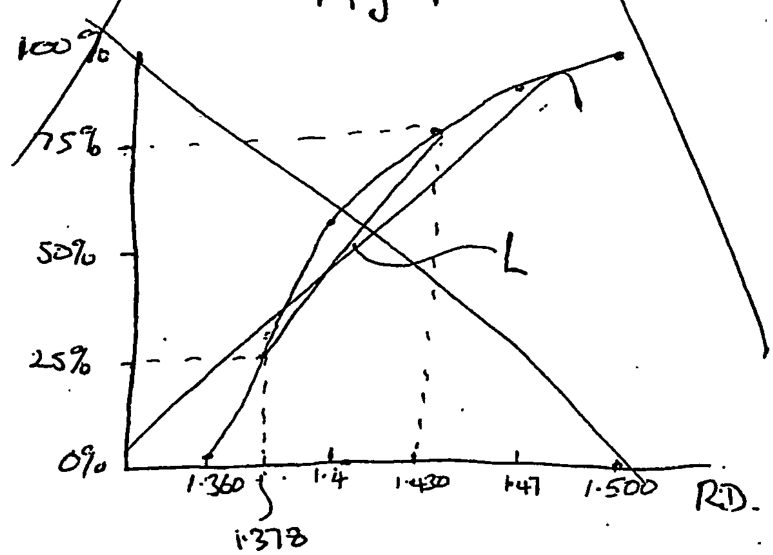

Fig 5

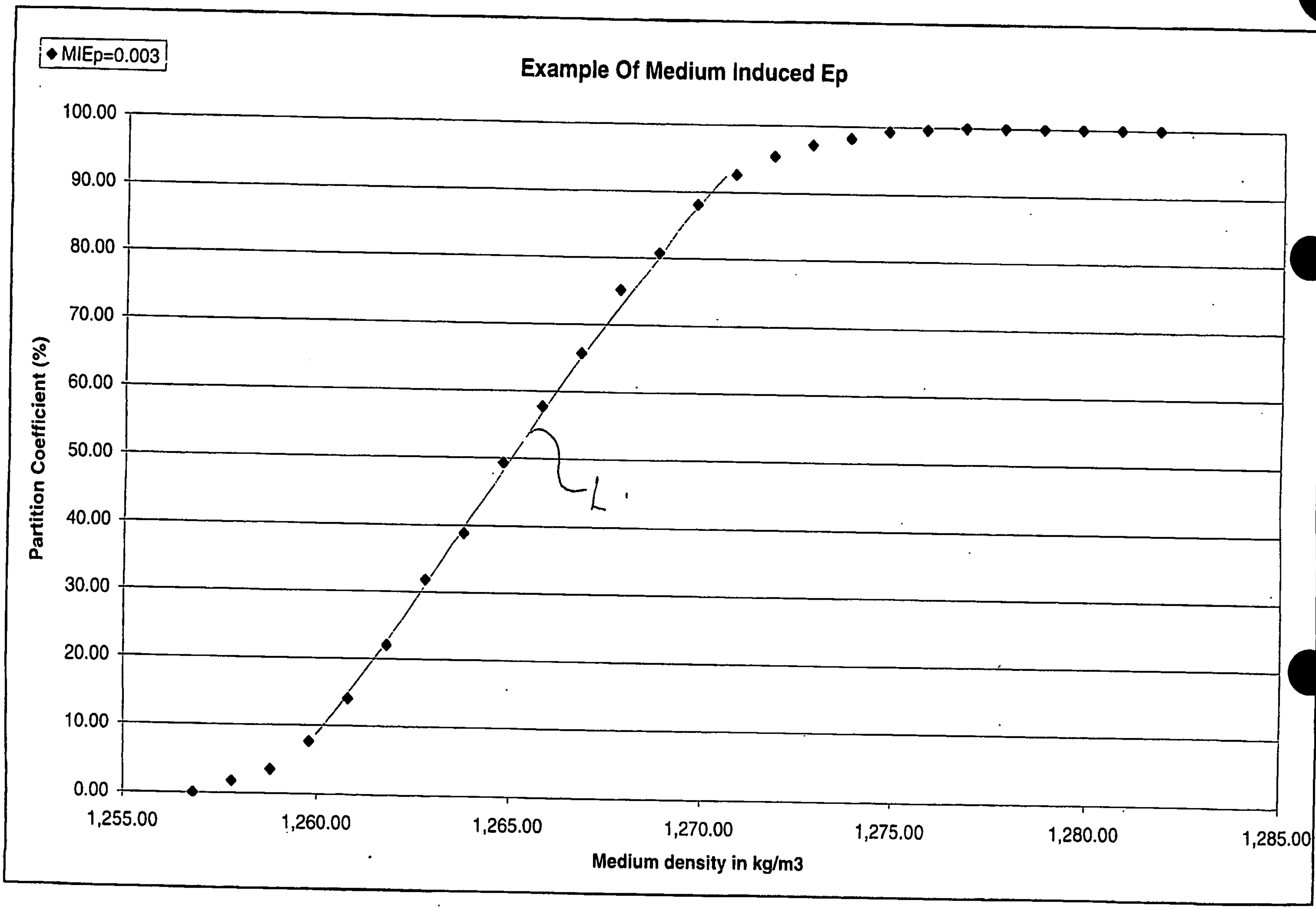
MIEp=0.003
Example Of Medium Induced Ep
Partition Coefficient (%)
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1,255.00
1,260.00
1,265.00
1,270.00
1,275.00
1,280.00
1,285.00
Medium density in kg/m3
L

Fig 5